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Description

GAS TURBINE BUCKET TIP CAP

BACKGROUND OF INVENTION

[0001] The present invention relates to gas turbine blades or buckets and more particularly relates to a turbine blade tip cap with a number of cooling holes therein.

[0002] Gas turbine components are exposed to the very high temperatures of the combustion gas flow therethrough. The components generally are cooled by a means of a cooling airflow so as to maintain structural integrity and promote longevity. Efficient use of the cooling airflow not only may prolong the life of the turbine blades but also may promote overall lower engine operating costs.

[0003] The gas turbine blades or buckets pose a particular technical challenge for cooling. The tip portion generally includes a tip cap and also may include a tip squealer extending radially away from the tip cap. The tip squealer provides rub tolerance in the event that the tip clearance is diminished during turbine operation. The tip squealer further increases the challenge of cooling the tip because

access to the squealer generally is limited.

[0004] Known cooling methods generally include several cooling holes positioned within the tip cap. The holes generally extend from a cooling passage or passages within the blade through the tip cap. The stresses and high temperatures present during normal operation of the turbine, however, may cause excessive oxidation, cracking, and creep bulging in the known tip caps.

[0005] In addition to cooling, the holes in the tip cap allow dust in the blade to vent. This venting also may improve overall efficiency. The tip cap also serves to close the blade core. Such closure is required for casting.

[0006] There is a desire, therefore, to optimize the shape of the tip cap. The tip cap may optimize the cooling fluid flow therethrough, allow dust to vent, and provide improved material characteristics.

SUMMARY OF INVENTION

[0007] The present invention thus provides a tip cap for a turbine blade. The tip cap may include a HS-188 sheet material with a thickness of less than about 0.079 inches (about 2 millimeters) and a number of holes positioned in the sheet material.

[0008] The tip cap may include six (6) holes. Each of the holes

may include a diameter of about 0.04 inches (about 1.06 millimeters). The holes may be positioned on the sheet material according to the coordinates set forth in Table I. The sheet material may include a thickness of about 0.062 inches (about 1.57 millimeters). A weld may be created by electron beam welding so as to attach the tip cap to the turbine blade.

[0009] A further embodiment may provide for a tip cap for a turbine blade. The tip cap may include a sheet material and a number of holes positioned within the sheet material. The holes may include a position on the sheet material according to the coordinates set forth in Table I.

[0010] The sheet material may have a thickness of less than about 0.079 inches (about 2 millimeters). The thickness may be about 0.062 inches (about 1.57 millimeters). The sheet material may include a HS-188 sheet material. Each of the holes may include a diameter of about 0.04 inches (about 1.06 millimeters).

[0011] A further embodiment may provide for a turbine blade. The turbine blade may include an airfoil and a tip cap position about a first end of the airfoil. The tip cap may include a sheet material with a thickness of less than about 0.079 inches (about 2 millimeters) and a number of holes

positioned therein. Six (6) holes may be used.

[0012] The holes may include a diameter of about 0.04 inches (about 1.06 millimeters). The holes may be positioned on the sheet material according to the coordinates set forth in Table I. The sheet material may include a thickness of about 0.062 inches (about 1.57 millimeters). A weld created by electron beam welding may attach the tip cap to the first end of the airfoil.

[0013] These and other features of the present invention will become apparent upon review of the following detailed description of the preferred embodiments when taken in conjunction with the drawings and the appended claims.

Brief Description of Drawings

[0014] Fig. 1 is a perspective view of a prior art turbine blade having a tip cap with cooling holes therein.

[0015] Fig. 2 is a top plan view of a tip cap as described herein positioned on a turbine blade.

[0016] Fig. 3 is a side cross-sectional view of the tip cap within the turbine blade of Fig. 2.

[0017] Fig. 4 is a further side cross-sectional view of the tip cap within the turbine blade of Fig. 2.

Detailed Description

[0018] Referring now to the drawings, in which like numerals indicate like elements throughout the separate views, Fig. 1 shows a prior art gas turbine bucket or blade *10*. The bucket or blade *10* may include an airfoil portion *12* having a pressure side *14* and a suction side *16*. The airfoil *12* also may include a base *18* for mounting the airfoil *12* to a rotor. The base *18* may have a platform *20* rigidly mounting the airfoil *12* and a root *22* for attaching the blade *10* to the rotor.

[0019] At an outer end portion *24*, the airfoil *12* may have a tip cap *26*. The tip cap *26* may have a number of cooling holes *28* positioned therethrough. The cooling holes permit the passage of the cooling airflow from the interior of the blade *10* so as to cool the tip cap *26* and to allow dust to vent therethrough. A squealer tip *30* also may surround the tip cap *26*. Specifically, the tip cap *26* may sit in a tip recess *32* surrounded by the squealer tip *30*.

[0020] Figs. 2-4 show an example of a tip cap *100* of the present invention. The tip cap *100* generally has the shape of the airfoil *12* or a portion thereof. The tip cap *100* may have a number of cooling holes *110* extending therethrough. Specifically, a first cooling hole *120*, a second cooling hole *130*, a third cooling hole *140*, a fourth cooling hole *150*, a

fifth cooling hole *160*, and a sixth cooling hole *170*. The cooling holes *110* may have a specific position along the tip cap *100*. Table I below shows the coordinate values for the X and Y coordinates expressed in inches (and in millimeters) for each cooling hole *110* from a Point A as is shown:

[0021] Table 1

Hole	X	Y
120	-1.572 inch (-39.93 mm)	0.467 inch (11.86 mm)
130	-1.336 inch (-33.93 mm)	0.605 inch (15.37 mm)
140	-1.060 inch (-26.92 mm)	0.680 inch (17.27 mm)
150	-0.702 inch (-17.83 mm)	0.681 inch (17.30 mm)
160	-0.373 inch (-9.47 mm)	0.560 inch (14.22 mm)
170	0.091 inch (2.31 mm)	0.158 inch (4.01 mm)

[0022] Each cooling hole *110* may have a diameter of about 0.04 inches (plus or minus about 0.002 inches) (about 1.06 millimeter plus or minus about 0.05 millimeter). The cooling holes *110* may pass through the tip cap *100* in a sub-

stantially perpendicular fashion to the tip cap surface. The position of these cooling holes *110* has been found to optimize the cooling of the tip cap *100*.

[0023] The tip cap *10* may have a thickness of about 0.062 inches (about 1.57 millimeters). The thickness of the tip cap *100* also has been found to maximize to cooling of the tip cap *100*.

[0024] The tip cap *100* may be made from a sheet material *175*. Specifically, a HS-188 sheet material (AMS 5608). HS-188 may be a metal alloy, specifically a Haynes Super Alloy. The material has superior oxidation resistance and weldability. (Known tip caps used IN 625 with a thickness of about 0.05 inches (about 1.27 millimeters.)) The use of this material for the tip cap *100* also has been found to maximize to cooling of the tip cap *100* as well as provide the improved oxidation resistance and weldability.

[0025] The tip cap *100* may be used with a bucket or blade *10* such as a stage one blade of a "7FA+E"turbine sold by the General Electric Company of Schenectady, New York. Such a turbine may use ninety-two (92) of the blades *10* and the tip caps *100*.

[0026] As is shown in Figs 2-4, the tip cap *100* may be placed within the tip recess of a blade *10*. The tip cap *100* may

not completely fill the recess *32*. Rather, a second tip cap *180* also may be used. The tip cap *100* may sit on a tip cap shelf *190* within the recess *32* and may be held in place by one or more welds *200*. Electron beam welding or similar welding methods may be used.

[0027] The tip cap *100* also may be used to repair existing blades *10*. The existing tip cap *25* may be evaluated for oxidation, deformation, and cooling hole *28* depth. If necessary, the existing tip cap *25* may be removed and replaced with the tip cap *100* herein. Such a replacement also may increase the overall life of the bucket or blade. The combination of the material selection, the thickness of the material, the number of cooling holes *110*, and the location of the cooling holes *110*, individually and collectively, may provide the tip cap *100* herein with improved oxidation and creep resistance. This improved resistance may increase the life of the blade *10* and improve the overall efficiency of the turbine.

[0028] It should be understood that the foregoing relates only to the preferred embodiments of the present invention and that numerous changes and modifications may be made herein without departing from the general spirit and scope of the invention as defined by the following claims

and the equivalents thereof.